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ABSTRACT

The goal of the review is to identify the factors which promote student cognitive achievement as measured by several studies conducted in developing countries. The major tool of analysis which measures the relationship between the school inputs, like teacher quality and school facilities, and cognitive achievement is the educational production function (EPF). The EPF expresses the maximum product of an input combination in the existing state of technical knowledge. Family background characteristics, school inputs, peer group characteristics, and initial endowments are variables for the EPF which have an important effect on academic achievement. These are influenced by policy controlled variables however, and by exposure-to-learning variables. It seems that the current technology of formal education improves student cognitive achievement in developing countries. Results of the ten studies reviewed by this paper are summarized, showing which studies find a given schooling input to have a statistically significant impact on achievement following the traditional expectations of educators and economists. This review concludes that the determinants of student achievement are basically the same in both developing and developed countries. Moreover, the greatest gains in cognitive achievement occur simply because the student is removed from his home environment into his school environment. (Author/ND)

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THE DETERMINANTS OF SCHOOL ACHIEVEMENT IN DEVELOPING COUNTRIES: A REVIEW OF THE RESEARCH

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The Determinants of School Achievement in Developing Countries: A Review of the Research

Officials in developing countries are concerned about the efficient allocation of educational resources since education represents their largest, single budgetary expenditure. The efficiency of an educational system can be defined partly in terms of the net benefits to the person with more education compared to someone with less in terms of lifetime earnings, physical productivity or personal satisfaction. However, educational institutions do not directly produce these advantages; rather they equip the student with those attributes necessary to obtaining the ultimate benefits of his training. Such attributes are both cognitive -- academic achievement and manual skill -- and affective -- self-esteem, dependability, creativity, and motivation.

This review is not concerned with linking cognitive and affective attributes to their ultimate benefits, but with identifying the factors which promote student cognitive achievement as measured in school examinations. 1/ The major tool of analysis which measures the relationship between the school inputs like teacher quality and school facilities, and cognitive achievement is the educational production function (EPF).

The Educational Production Function

The production function expresses the maximum product of an input combination in the existing state of technical knowledge. Its nature and

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1/ See Gintis (1971) for a discussion of the relative benefits of cognitive and affective traits for the ultimate benefits; and Simmons and Noerenberg (1975) for data on developing countries.

underlying assumptions as a construct in the theory of the firm have been extensively examined (Aigner and Chu, 1968). In an educational context, it can be written generally as:

$$A_{it} = g\ (F_{i(t)}\ S_{i(t)},\ P_{i(t)},\ I_{i(t)}) \qquad (1)$$

where i refers to the i'th student, t refers to time, and (t) refers to an input cumulative to t. The vector A denotes educational outcomes, usually academic achievement, and the input vectors F, S, P, and I denote family background characteristics, school inputs, peer group characteristics, and initial endowments respectively.

To maximize output it is necessary that the marginal product of the last dollar spent be the same for all inputs. The policy prescription which emerges from this condition is to equate the ratios of marginal product to price over all inputs. However, if this prescription is applied to the input coefficients which emerge from an estimated EPF, efficient allocation of educational resources will almost certainly not result. This is because the estimated coefficients will not be unbiased estimates of the marginal products of the inputs of the true EPF.

There are five major sources of error which can bias the equation:

(a) Multiple output interaction: The educational process results in multiple outputs which interact; thus a higher self-esteem may also improve a student's academic achievement. Therefore

simultaneity bias will arise in the estimation of any single equation by ordinary least squares. 1/

(b) Misspecification of the functional form of EPF: There is no established theory of learning to serve as a guide to either the correct form of the EPF, or a priori limits on, its coefficients. In practice, an additive linear function has most commonly been used. However in some schools it may be unacceptable since it implies that the marginal products of the inputs are constant. 2/

(c) Data limitation: Bias can arise from measurement error -- a student's inaccurate recollection of family background characteristics -- or from the omission of a correlated input variable. 3/ For example, although student ability may be closely related to family background, the exact relationship may be difficult to measure. Similarly, teaching methods, frequently related to teacher experience, are usually omitted.

(d) Multicollinearity: The input vectors of background, school and peer group characteristics all tend to be positively related to the social class of the student. Thus the order in which variables are entered into the equation may affect the

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1/ Simultaneous equation models for U.S.A. include Levin (1970), and Boardman, Davis and Sanday (1973).

2/ Beebout (1972) tests 11 functional forms for use as educational production function surfaces and chooses the quadratic form on a priori grounds.

3/ These limitations are discussed in more detail in Bowles (1970) and Keisling (1971). Also see Christ (1966), p. 388.

observed statistical significance of the collinear variables (Johnston, 1972 , p. 160).

(e) Technical inefficiency of schools: There is no evidence to suggest that schools are efficiently managed (Levin, 1971a), yet the policy prescription of equating ratios of marginal products to input prices assumes that schools are operating at maximum efficiency. Since this is a false assumption, following the policy prescription for the estimated coefficients from an EPF would not result in optimal resource allocation, even if the coefficients were unbiased estimates of the slopes of the true production surfaces. Furthermore, the degree of inefficiency is likely to vary among schools. Therefore estimate will reflect an "average" production function. (Aigner and Chu (1968)). If the coefficient estimates were used as a policy guide, an allocatively inefficient decision would be imposed on the relatively more and less efficient schools, possibly decreasing the allocative efficiency of the educational sector as a whole.

One must conclude that these deficiencies prohibit automatic policy recommendation based on EPFs. However, the EPF is still a useful analytical tool for improving, rather than optimizing, the allocation of educational resources. 1/ Thus, the technical inefficiency of schools may not be an important practical problem. But the unavoidable bias in the input coefficient

1/ Since the "average" production surface as estimated describes the existing education system, it is sitll worthwhile to determine the alternative ways of both moving across the surface and shifting it up.

estimates will still remain, and will prevent them being used as point estimates of the true marginal products. The observed direction of the influence of various factors on schooling outputs may be correct, but the extent of their influence will not be.

A sensitivity analysis is therefore essential, whereby the cost effectiveness, or achievement gains per unit cost of a given input, is calculated for a range of values around the estimate of marginal achievement. Since additional assumptions must be made in determining unit input cost, testing a range of unit costs is also desirable. Cost-effectiveness ratios for different inputs can then be compared and used as the basis for policy decisions.

Student Cognitive Achievement in Developing Countries

Student academic achievement as measured by examination and other test scores has been the most extensively studied educational benefit both in developing and developed countries. A review of statistically valid EPF studies of primary and secondary student achievement in developing countries will determine the direction and general magnitude of the effect of various inputs on achievement. A consensus of results will lend greater weight to future EPF findings and to consequent policy recommendations for any individual country.

There are at least eighteen EPF studies on developing countries which are internally consistent in that they follow accepted procedures of multivariate analysis. 1/ The authors rejected those studies which were not

1/ See Bibliography, Part B.

readily available in English; did not examine cognitive achievement as a dependent variable; and did not test a wide range of input variables. The acceptable studies with their sample, statistical procedures and dependent variables are listed in Table 1 on page 7.

The independent variables tested in these studies cannot be listed in detail since they range from 5 in the Thias-Carnoy upper secondary school study to approximately 500 in the IEA studies. However, they can be summarized according to the Vector, or block to which they belong as shown in equation (1) above.

(a) Family background characteristics: variables describing the family's socioeconomic status. Some studies also include student, family, and local community expectations and attitudes toward education. Other studies place these variables in a separate block of "kindred variables" which modify the effects of the socioeconomic status.

(b) School inputs: variables describing the learning conditions in the school. While these variables include both school facility and teacher characteristics, the design of the study can prevent the effects of potentially important determinants of learning being revealed. For example, studies which average teacher characteristics for the school cannot detect the influence of varied teacher-student interactions operating in the classroom. The Carnoy-Thias (1974) and the International Educational Achievement (IEA) (1973) studies are an exception.

Table 1

DESCRIPTION OF EDUCATIONAL PRODUCTION FUNCTION STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN DEVELOPING COUNTRIES

Author (s) and Publication date	Country	Sample: Primary or Lower Secondary Grade	Sample: Upper Secondary Grade	Statistical Procedure	Measure of Student Academic Achievement
Thias-Carnoy 1969	Kenya	3,405 rural primary students in grade 7 in a random sample of 89 primary schools		O.L.S.+ multiple regression	Average student score on Kenya Preliminary Examination for each school
Thias-Carnoy 1969	Kenya		Students in 115 rural and urban schools in Form IV (grade 11)	O.L.S. log-linear multiple regression	Average student score on Cambridge School Certificate Examination for each school
Carnoy 1971	Puerto Rico	182,000 students in grades 3, 6, 9 and 12 of all public schools		O.L.S. and two stage least squares multiple regression	Average student score on a Spanish reading examination for each school*
Youdi 1971	Congo		1,430 students in grades 11 in a random sample of 89 secondary schools	Stepwise O.L.S. multiple regression	Individual scores on IEA*** multiple choice tests in French and mathematics
Simmons 1972	Tunisia	44 students from a village and 80 students from an urban suburb, all in grades 4 to 8		Stepwise O.L.S. multiple regression	Individual scores on multiple choice tests in Arabic, French and arithmetic
Beebout 1972			7,674 students in grades 10 and 11 in a random sample of 89 secondary schools	O.L.S. multiple regression using both a quadratic and linear functional form	An index of individual student performance relative to that of his peers; performance defined as the difference between secondary entrance and final examination scores
Comber and Keeves, Thorndike 1972	Chile, India, Iran Thailand	258,000 students in 9,700 schools randomly selected in 15 developed countries and 4 developing countries. Three populations were tested -- primary students aged 10, lower secondary students aged 14 and students in the terminal upper secondary year		Stepwise O.L.S. multiple regression	Individual scores on internationally developed multiple choice tests in science and native language reading comprehension**
Schiefelbein-Farrell 1973	Chile	353 randomly selected 8th grade classes in both primary and secondary schools with an average response of 10 students per class		O.L.S. multiple regression and commonality analysis	Individual scores on national 8th grade test in Spanish and arithmetic
Ryan 1973	Iran	797 2nd grade students selected randomly from 66 rural schools in 2 provinces		O.L.S. multiple regression and commonality analysis	Individual scores on multiple choice tests in Persian and arithmetic
Carnoy-Thias 1974	Tunisia	6,195 students in grades 7, 8, 8, 10 and 11 randomly selected from rural and urban secondary schools		Stepwise O.L.S. multiple regression	Individual student grade point average on school examinations.

*Other Endogenous variables in the simultaneous equation model were the student's expected level of schooling, self-esteem, and desire to transfer in another school.

**(IEA) - International Association for the Evaluation of Education and Achievement.

***Other subjects tested were literature, French as a foreign language, English as a foreign language, and civics.

+(OLS) - Ordinary Least Squares.

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(c) Peer group characteristics: variables measuring the influence of other students' attitudes and performances on the individual's achievement. Most studies, however, do not specifically include this block, exceptions being Simmons (1972) and Schiefelbein-Farrell (1973).

(d) Initial endowments: variables describing the characteristics of the student - IQ at school entry, age and sex. In no study is a direct measure of ability like IQ included. Some studies, however, of upper secondary achievement include a proxy score on a secondary entrance examination. This attempts to summarize the impact of all prior influences, including that of IQ on performance.

The influence of schooling variables on achievement, both absolutely and in relation to other variables, is of primary importance in policy decisions. However in some studies the schooling block consists of two groups of variables:

(a) Policy controlled variables: These affect resource allocation within an educational system - for example, teacher quality, student/teacher ratio, school size, availability of boarding accommodation, and size of library facilities.

(b) Exposure to learning variables: These are either:

(i) not subject to policy control - for example, the number of years a student has already attended his present school; or

(ii) are subject to policy control - for example, changing the size of the educational system by allowing the student to obtain more schooling.

These exposure to learning variables reflect the specific exposure a student has received in the school environment distinguishing between the specialist and the non-specialist student.

To improve policy decisions, it is necessary to distinguish between the influence of policy and exposure variables when interpreting the results of a given study.

The findings of the studies in Table 1 reveal that some school variables do have an important effect on academic achievement. For many variables, however, especially those which are subject to policy control and traditionally thought to be important, the effect is insignificant. Furthermore, the effect of any significant policy variables is small in relation to other determinants of performance such as exposure to learning and home background variables. There is such inconsistency in the effect of a given policy controlled variable on achievement that we can tentatively suggest only a few to improve the internal efficiency of an educational system in the country for which there are data. Thus additional EPF and experimental studies of the country in question should be undertaken before policy decisions are made.

The Relative Importance of Schooling Variables and Other Inputs

Home background or parental socioeconomic status strongly influences student performance at primary and lower secondary grades for all subjects

tested. In these grades, home background generally has a stronger effect on achievement than the policy controlled schooling variables. (For example, the Simmons study for Tunisia (1972) finds parental socioeconomic status to be significant at the .01 level, whereas schooling variables are usually significant at the .05 or .10 levels. Also, the IEA study in Chile, India, Iran and Thailand (1973) of reading comprehension at primary grades finds that although home background variables explain between 1.5% and 8.7% of variance in test scores, most policy controlled schooling variables are not statistically significant and explain hardly any of total variance. The only policy variable consistent across many countries is hours of homework per week and it accounts for only 0.6% of total variance. However, there are exceptions to this general finding, depending on the composition of the sample and the subject being tested.

The Ryan study for Iran (1973) covering only rural and village students finds from a commonality analysis 1/ that school and teacher variables combined explain more of the variance in achievement scores than do home and community variables combined. Since urban students are excluded from the sample, the variance in family socioeconomic status for the rural sample is small and the contribution of home background is thereby reduced. Also, the IEA science study (1973) of primary students shows that while home circumstances explain between 0% and 4% of test score variance, policy controlled schooling variables have about the same explanatory power. Finally, it is

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1/ Commonality analysis partitions the total R^2 into the unique effect of each set of variables and the joint effect of each possible combination of variable sets. Refer to Mayeske (1970).

possible that the relative influence of schooling variables is underestimated by single equation estimation of the EPF. The structural form results of the Carnoy study for Puerto Rice (1971) indicate that home background has a smaller influence, and schooling variables a larger influence on achievement compared to the reduced form results. However, repetition of this finding would depend on the investigator's choice of endogenous schooling outputs, and the empirical interrelationships between them.

Although home background is important in primary and early secondary grades, its influence diminishes as the student proceeds through the secondary cycle. Eventually, policy controlled schooling variables have a greater influence on performance in the upper secondary grades. This is evidenced by the four studies which cover many grade levels - Carnoy-Thias for Tunisia (1974), Carnoy for Puerto Rico (1971), and the IEA studies. For example, in the IEA study of terminal secondary science achievement (1973), the average contribution of home circumstances is between 0% and 2%, while schooling policy variables explain over 4% of total variance. Only the Beebout study (1972) of upper secondary students being instructed in the Malay language indicates that socioeconomic status is important.

The Schiefelbein-Farrell study (1973) argues that for the lower secondary grades the influence of the peer group is greater than that of home background. A commonality analysis indicates that the unique contribution of peer group variables is twice that of student background characteristics. However, the variable, "average possession of a T.V. set in the home per class," has a high Beta coefficient and is included in the peer group variables. Since

this variable probably should be included in the home background block, doubt is thrown on the strong impact of the peer group variables. Also, no other study indicates peer group impact to exceed that of home background.

An important finding for primary and lower secondary grades is that home background accounts for less of the variation in student performance in developing countries than in the developed countries. The IEA studies do give evidence for this finding. Of the variation in primary science achievement, home circumstances explain 8% on average over all countries, but only from 0% to 4% in developing countries. For lower secondary science achievement, the equivalent figures are 10% and from 2% to 9% respectively. For primary reading achievement, the developing country contribution is between 1.5% and 8.7%, compared to 14% on average over all countries.

On initial consideration this finding would indicate a potentially greater role for schooling variables in improving student achievement in developing countries. This interpretation appears to be consistent for primary and lower secondary grades as evidenced by the greater than average contribution of <u>all</u> schooling variables to achievement in developing countries in both the IEA studies. Schooling variables explained from 6% to 20% of developing country primary science achievement, compared to an average across all countries of 8%. However, on closer examination we found that exposure to learning variables, and not policy controlled variables, accounted for much of the contribution, and this explains why the contribution of home background is greater than that of the policy controlled variables for these grades. The greater contribution of "exposure" variables can be seen from a comparison

of the size of the statistically significant Beta coefficients emerging from the regressions. For IEA science achievement in these grades, exposure to learning variables account for around 60% of the total impact of the schooling variables block.

This finding suggests that the current technology of formal education does improve student cognitive achievement in developing countries, but that it is effective mainly through the accumulated exposure of a student to a learning environment. Policies that alter the allocation of schooling inputs under existing technologies are likely to have a minimal impact on student achievement at primary and lower secondary grades. However, although exposure to learning variables are important in upper secondary grades, policy controlled schooling variables have an equivalent or greater impact on achievement. This indicates that the efficiency of existing educational systems in these grades can be substantially improved.

The Direction of Effect of Individual Policy Variables on Achievement

The findings of all studies reviewed by this paper are summarized in Table 2 below. It shows which studies find a given schooling input to have a statistically significant impact on achievement following the traditional expectations of educators and economists and which studies do not.

TABLE 2

RESULTS OF EDUCATIONAL PRODUCTION
FUNCTION STUDIES FOR DEVELOPING COUNTRIES

Variable, and its Relationship to Student Performance			
Variable	Expected Sign	Statistically Significant with Expected Sign	Not-Statistically Significant, or with Opposite Sign
Boarding at secondary grade	+	Thias-Carnoy (grade 11) Carnoy-Thias Youdi	Beebout
Grade repitition	-	Thias-Carnoy (grade 7) Simmons-Youdi	Beebout
Double sessions	-	Beebout	S'bein-Farrell
Size of school enrollment at upper secondary grades	?	(+) Thias-Carnoy (grade 11) IEA science	(-) Beebout Youdi
Performance and attitudes of classroom peer-group	+	Carnoy-Thias S'bein-Farrell (?)	
Per pupil expenditures on school facilities or teachers	+		Thias-Carnoy (grade 11) Beebout
Average class size, or pupil:teacher ratio	-	Carnoy Beebout Ryan	Thias-Carnoy (grade 7) S'bein-Farrell IEA science IEA reading
Teacher certification and academic qualification at primary and lower secondary grades	+	Carnoy	Ryan Thias-Carnoy (grade 7) S'being-Farrell
Teacher certification and academic qualification at upper secondary grades	+	Beebout Youdi IEA science	Carnoy-Thias Carnoy
Teacher contract (tenure) at upper secondary grades	+	Carnoy	Carnoy-Thias

TABLE 2
(Continued)

RESULTS OF EDUCATIONAL PRODUCTION
FUNCTION STUDIES FOR DEVELOPING COUNTRIES

Variable, and its Relationship to Student Performance			
Variable	Expected Sign	Statistically Significant with Expected Sign	Non-Statistically Significant, or with Opposite Sign
Teacher experience at primary and lower secondary grades	+	Thias-Carnoy (grade 7) S'bein-Farrell Carnoy	Carnoy-Thias
Teacher experience at upper secondary grades	+	Beebout	Carnoy-Thias Carnoy Youdi
Teacher sex - males at primary and lower secondary grades; females at upper secondary grades	+	Carnoy-Thias Beebout IEA science IEA reading	Thias-Carnoy (grade 7) Carnoy Youdi
Teacher motivation	+	Ryan IEA science	
Textbook availability at primary grades	+	S'bein-Farrell IEA science	
Availability and use of library	+	Beebout IEA reading	
Homework and free reading at home	+	S'bein-Farrell Simmons IEA science IEA reading	

Table 3 below indicates the ten different countries in which the studies were made.

TABLE 3

Beebout	Malaysia
Carnoy	Puerto Rico
Carnoy and Thias	Tunisia
Comber and Keeves	Chile, India, Iran, Thailand
Epstein	St. Lucia
Schiefelbein and Farrell	Chile
Simmons	Tunisia
Thias and Carnoy	Kenya
Thorndike	Chile, India, Iran
Youdi	Congo

One policy controlled variable which also intensifies the exposure to learning environment, and hence the student's academic achievement, is the provision of boarding facilities at the secondary school. This is evidenced in the Carnoy-Thias studies for Kenya and Tunisia and in the Youdi study for the Congo. (These authors show that the effect of boarding is independent of home background influence.) The studies show that "boarding" has a greater impact that any other policy controlled variable. We should note, however, that boarding may be a proxy for more study time, fewer distractions, and increased financial motivation. The Beebout study for Malaysia, on the other hand, finds that boarding is not statistically significant.

It is obvious, therefore, that no general recommendations can be made to developing countries about boarding without further EPF and experimental studies. It can only be regarded as a potentially important aid in increasing student performance. Furthermore, attempts should be made to determine if the learning environment associated with the boarding schools can be provided without incurring the consequent expense.

Other policy variables have a positive influence on performance in some studies, but a negative or no influence in others. Collectively, the results again stress the need for individual EPF and experimental studies of a given education system within any country before policy recommendations can be made. One of these ambivalent variables is the use of double sessions at primary and early secondary grades in order to extend formal education to more students. Schiefelbein-Farrell find that double sessions have a positive influence on achievement, whereas Beebout finds the opposite.

A larger school size at the upper secondary level was found to be important by both Thias-Carnoy and IEA, possibly because larger schools have better teaching aids and facilities. However, Beebout and Youdi found a larger enrollment to be detrimental to performance, perhaps because smaller schools have superior facilities in Malaysia and the Congo.

A traditionally important variable for the internal efficiency of schooling as argued by educators is class size or the pupil:teachers ratio within the range 25 to 45 students. The larger the class size or higher the pupil:teacher ratio, the lower the student achievement. Four studies, including both IEA studies in Chile, Thailand and elsewhere found this assertion to be incorrect. However, in Puerto Rico, Malaysia, and the Congo, a larger

class size did in fact have a negative impact on performance. These countries were not in the IEA sample.

Further disagreement occurs about the influence of teacher characteristics on student performance. Although once again, no general policy recommendations for these variables can be made, each of the following conclusions is suggested by the majority of studies.

(a) Teacher certification and academic qualification are not important at primary and lower secondary grades. However, they appear to be important at upper secondary grades in some subject areas, given the agreement across developed and developing countries in the IEA science study regarding the significance of post-secondary schooling of teachers.

(b) The percentage of teachers on permanent contract (tenure) is not important in primary and lower secondary grades. However, it may have a positive or negative influence in upper secondary grades depending on the country being examined. This agnostic conclusion is evidenced by the IEA science study and the Thias-Carnoy Kenya study respectively.

(c) Teacher experience does have a positive influence on performance in primary and lower secondary grades. For example, teacher salary is significant in the Thias-Carnoy Kenya study, and this reflects teacher seniority,

and experience. In upper secondary grades, teacher experience is not important.

(d) Teacher sex has a changing impact on performance. Male teachers positively influence male students from grades 5 to 8, but have a negative influence on students of both sexes at the upper secondary level. However, the negative influence of male teachers is evident in the Carnoy Puerto Rico study by the 8th grade. At higher levels, female teachers positively influence female student performance.

Finally, there are the few instrumental policy variables which are consistently significant in the studies in which they are tested. These are the variables which should receive the greatest attention of policy makers interested in making interim decisions without undertaking additional research. The studies indicate that:

(a) Gross expenditure variables such as cost of school facilities per student or average teacher salary are not important predictors of student performance. Thus, unit costs, particularly at the secondary and higher levels, could be significantly lowered without affecting performance.

(b) Teacher motivation as indicated by the actions of teachers - for example, the time spent in lesson preparation and membership of curriculum reform committees - is positively related to performance. Beebout comes to the opposite conclusion, but his motivation variable

reflects the opinions of headmasters about their teachers' motivation and not the actions of the teachers themselves. Policy should, therefore, be directed toward identifying highly motivated teachers.

(c) Textbook availability at the primary level is an important predictor of performance in developing countries. 1/ An associated variable is the availability and use of a library at primary and early secondary grades. The policy implications include supplying a minimum number of texts or reading materials to all students.

(d) The amount of homework performed by students, the physical conditions of home study, and the amount of reading performed at home are important predictors of student school achievement. All these variables indicate that the more a student can be exposed to a learning environment in the home, the higher will be his achievement level. Policy makers should ensure that teacher training courses promote the use of homework as a teaching method, and that students are at least provided with adequate conditions for home study and free reading.

Thus, the only variables that can be recommended to possibly improve the internal efficiency of educational system in developing countries for which

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1/ This result indicates that threshold levels of some inputs may exist in developing countries. Textbooks may significantly affect achievement up to a certain level of textbook ownership, but not above this level when ownership is more widespread as in developed countries.

there are data concern the reduction of unit costs, teacher motivation, textbooks and other reading materials, and homework. A word of caution, however, is required. These recommendations could "possibly" improve internal efficiency, but they are not a guarantee. If policy makers are looking for ideas to experiment with on a limited number of schools to see if improvements could be made, then our recommendations are one place to start. There is no suggestion that success is assured. Specific recommendations on the basis of teacher characteristics, for example, have to be postponed pending additional study.

We can recommend certain methods for conducting this research. In contrast to most of the reviewed studies, future EPF studies should examine multiple schooling outputs rather than analyze one in isolation like achievement. Variables such as academic achievement, the drop-out rate, modernity, motivation, and self-esteem should be treated as simultaneously determined outputs. Two stage least squares estimations should be a preferred statistical procedure, especially as the functional form of the equations in the system, other than the one being estimated, does not have to be specified. Also, further interaction with other disciplines to improve measurement, especially psychology and anthropology, should be made for a substantive improvement in results to emerge. Refining the measures for student and teacher motivation and schooling outputs is possibly the first step in this process. 1/

1/ A study which attempts to define a measure of academic motivation for 11th grade Puerto Rican students is Farquhar and Christensen (1968). Its aim is to determine the influence of child rearing and other psychological-sociological factors on motivation and thence on academic achievement. Some psychologically interpretable instruments are suggested. For a catalogue of these measures for the U.S. see Ralph Hoepfner (1972).

These procedures should provide a sound basis for sensitivity analysis of the cost effectiveness of the inputs suggested by EPF research, which is a necessary condition for valid policy recommendations. However, given limited research resources, it may be more fruitful for countries where prior EPF research has already suggested important educational inputs to further test the cost effectiveness of these inputs by experimental research techniques rather than by repeating the EPF approach.

Conclusion

This review concludes that the determinants of student achievement are basically the same in both developing and developed countries. This view is supported by the repeated consistency of the direction of influence on achievement of the variables tested in the IEA studies for all twenty-three countries. Studies which summarize educational production functions in the United States, for example, Keisling (1971) have also reached this conclusion. However, important difference arises because of the lower incidence in developing countries of home conditions which are conducive to learning and lower than threshold levels of reading material. But it is significant that factors which have traditionally been regarded as essential for better education - higher quality teachers, more expensive facilities - do not seem increase achievement at lower grade levels even in the poorest countries. Instead, the greatest gains occur simply because the student is removed from his home environment into a school environment. Therefore, policies that give a student a longer exposure to learning at school will, on the average, have a significant impact on his cognitive achievement. By the time the student has reached upper secondary grade levels, the accumulated exposure to a

learning environment enables school facility and especially teacher quality variables to influence achievement more heavily in some countries.

Finally, regardless of the grade level, policies designed to improve educational efficiency must be as cost-effective as possible, given the limitations imposed by data and available techniques of analysis. The importance of the educational production function to identify important policy controlled determinants of achievement in a specific educational system, and, when used in conjunction with cost analysis and experimental design, to determine those which have the greatest cost-effectiveness, is evident.

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